ELECTROSTATICS

QUANTIZATION OF CHARGES

All charges must be integral multiple of e i.e.
Q = Ne (e = 1.6 × 10⁻¹⁹C)
where —N = integer

CONSERVATION OF CHARGES

It is not possible to create or destroy net charge of an isolated system

ELECTRIC CHARGES

- Charge is an intrinsic property of matter by virtue of which it experience Electric & Magnetic Effect
- Two kinds of charges +ve and -ve
- S.I. Unit Coulomb(c)

ELECTRIC DIPOLE

A pair of Equal and opposite point charges repeated by fix distance

Electric Dipole Moment

$\vec{P} = q(2a)\ cm$

- Electric field due to Electric Dipole
  (i) Electric Field (E.F.) on the axis of dipole at a distance r from center of dipole:

$$E = \frac{-kq}{(r-a)^2} + \frac{kq}{(r+a)^2} = \frac{k2qa^2}{(r^2-a^2)^2}$$

  (ii) Electric field at a distance r from centre of dipole on its Equatorial line:

$$E_{net} = \frac{-k\vec{P}}{(r^2+a^2)^{\frac{3}{2}}}$$

- Electrical potential due to Electric Dipole:

(i) Axial $\rightarrow V_p = \frac{KP}{(r^2-a^2)}$

(ii) Equatorial $\rightarrow V_p = 0$

- Force and Torque on dipole in Uniform external (E.F.)

Force $\rightarrow \vec{F}_{net} = q\vec{E} - q\vec{E} = 0$

Torque $\rightarrow \vec{L} = PE\sin\theta = \vec{P} \times \vec{E}$

Work Done in Rotating Dipole $\rightarrow W = PE(\cos\theta_1 - \cos\theta_2)$

- Potential Energy $\rightarrow U = -PE\cos\theta = \vec{P}.\vec{E}$

ELECTRIC FLUX

Total Number of electric field lines passing normally throng an area

$-\phi = \oint \vec{E}.d\vec{S}$

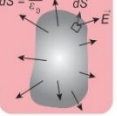
Electric Flux $(\phi) = |\vec{E}||\vec{dS}|\cos\theta$

GAUSS LAW

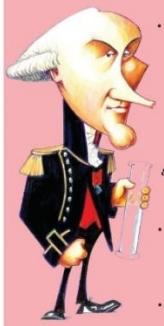
It States, total flux of an E.F. through a closed surface is equal to times of total charge enclosed by the surface.

Total flux through surface

$(\phi) = \frac{q_{enclosed}}{\varepsilon_0}$ $\oint \vec{E} \cdot d\vec{S} = \frac{q}{\varepsilon_0}$



COULOMB'S LAW



- Force between two charged particles

$\vec{F} = \frac{Kq_1q_2\vec{r}}{r^3} = \frac{Kq_1q_2\hat{r}}{r^2}$

$k = \frac{1}{4\pi\varepsilon_0} = 9\times10^9\ NM^2C^{-2}$

ε_0 = Permitivity of Free Space $= 8.854\times10^{-12}\ C^2\ /\ Nm^2$

- Forces in Vector Form

$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{|\vec{r}_1-\vec{r}_2|^3}(\vec{r}_1-\vec{r}_2)$

- Forces between Multiple Charges

$\vec{F}_{net} = \frac{q_0}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_{oi}^2}\hat{r}_{oi}$

ELECTRIC FIELD

- Electric field intensity (E) $\Rightarrow \vec{E} = \lim_{q_0 \to 0}\frac{\vec{F}}{q_0}$

In vector Form— $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\hat{r}$

S.I Unit $\frac{N}{C} = \frac{V}{m}$

- Electric Field Intensity due to Point charge Q

$(E) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

- Net Electric Field with respect toorigi

$E_{net} = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_{oi}^2}\hat{r}_{oi}$

- Electric field due to finite length line charge at distance r from conductor

$E_{\parallel} = \frac{\lambda}{4\pi\varepsilon_0 r}\left[\cos 0 - \cos\frac{\pi}{2}\right]$

$E_{\perp} = \frac{\lambda}{4\pi\varepsilon_0 r}\left[\sin\phi_2 + \sin\phi_1\right]$

(Here, l is linear charge density)

Case(I): E.F due to Infinite line charge

$\phi_1 = \phi_2 = \frac{\pi}{2} \rightarrow F_1 = \frac{\lambda}{2\pi\varepsilon_0 r}: E_{\parallel} = 0$

Case(II): E.F due to Semi-Infinite line charge

$\phi_1 = \frac{\pi}{2}. = \phi_2 = 0 \rightarrow E_{\parallel} = F_{\perp} = \frac{\lambda}{4\pi\varepsilon_0 r}$

- Electric Field due to a charged Circular ring at a point on its Axis.

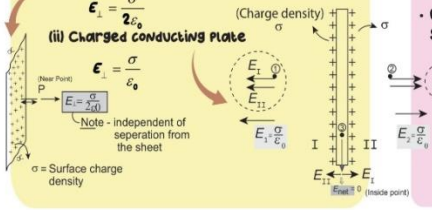
$E_p = \frac{kQx}{(R^2+x^2)^{\frac{3}{2}}}$

- Electric field due to a Plane Infinite Sheet
  (i) Non-Conducting Sheet:

$E_{\perp} = \frac{\sigma}{2\varepsilon_0}$

(ii) Charged Conducting Plate

$E_{\perp} = \frac{\sigma}{\varepsilon_0}$



σ = Surface charge density

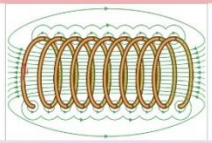
THEORY OF CONDUCTOR

A material having free electrons in its valence shell is called conductor.

- Inside a conductor, the Net electrostatic field is zero
- At the surface of a charged conductor, the electrostatic field must be normal to the surface at every point
- The interior of a conductor can have no excess charge in the static situation i.e. excess charge reside only on the outer surface of conductor.
- Electric field at the ssurface of a Charged conductor

$-\left[E = \frac{\sigma}{\varepsilon_0}\right]$ where, σ is Surface charge density.

$$\left(\sigma = \frac{1}{\text{radius of curvature}}\right)$$



- Electric field due to charged Spherical Shell or Conducting Sphere

$E = (r < R) = 0$

$E = (r > R) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

$E = (r = R) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R^2}$

- Electric field due to a Solid Non-Conducting Sphere - (r = Volume charge density)

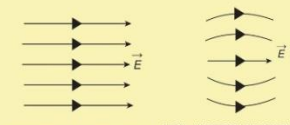
$E = (r < R) = \frac{kQr}{R^3} = \frac{\rho r}{3\varepsilon_0}$

$E = (r > R) = \frac{kQ}{r^2} = \frac{1Q}{4\pi\varepsilon_0 r^2}$

$E = (r = R) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R^2}$

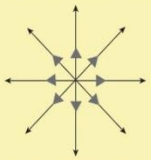
ELECTRIC FIELD LINES

- Aways normal to conducting surface.
- Lines originating from +ve charge
- Terminating at -ve charge
- Never intersect Each other.
- Never form closed loop.
- Electric Field lines are imaginary.
  (i) Uniform Electric Field
  (ii) Non-Uniform E.F.
  (iii) Radial Electric Field



UNIFORM ELECTRIC FIELD

NON- UNIFORM ELECTRIC FIELD



RADIAL ELECTRIC FIELD

ELECTRIC POTENTIAL & ELECTRIC POTENTIAL ENERGY

- Work done By External charge to move from postion 1 to 2 in Static Electric Field E.

$W_{ex} = \int_1^2 \vec{F}.\vec{dl} = -q\int_1^2 \vec{E}.\vec{dl}$

- Electric Potential

$\rightarrow V_p = \frac{W_{ex}(\infty \rightarrow P)}{q} = -\int_{\infty}^{P}\vec{E}.\vec{dl}$

- Electric Potential due to a Point charge in its Surrounding: $\rightarrow V_p = \frac{Kq}{r}$
- Electric Potential due to a Point charged ring at its center:

$V = \int dV = \int\frac{Kdq}{R} = \frac{K(\ )}{R}$

- Electric Potential due to Conducting and Non-Conducting Sphere:
  (i) Inside (r < R)
  (ii) Outside (r > R)
  (iii) At Surface (r = R)

Hollow Conducting

$V_p = \frac{Kq}{R}$

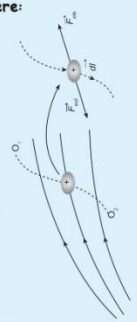
$V_p = \frac{Kq}{r}$

$V_p = \frac{Kq}{R}$

Solid Non-Conducting

$V_p = \frac{Kq}{2R^3}\left[3R^2 - r^2\right]$

$V_p = \frac{Kq}{r}$ $V_p = \frac{Kq}{R}$



- Electric Potential Energy: Amount of work done(w) required to be done to move a charge from infinity to any given point inside the field.

$U_A = W_{\infty \rightarrow A} = -q\int_{-\infty}^{A}\vec{E}.\vec{dl} = qV_A$

- Work done in moving charge from A to B will be:

$W_{ex} = \Delta U = (U_B - U_A) = q(V_B - V_A)$

- Electric Potential Energy due to two Point charges:

$U = \frac{Kq_1q_2}{r}$

- Electric Potential Energy of a System of charges:

$U_{(Total)} = Kq_1q_2\frac{1}{r_{12}} + Kq_1q_3\frac{1}{r_{23}} + \frac{Kq_3q_4}{r_{34}} + \ldots$

- Relation Between Electric Field and Potential:
  Electric Field at a point is negative of potential gradient

Potential gradient $\rightarrow \left[E = \frac{-dV}{dr}\right]$

NCERT LINE BY LINE QUESTIONS

1. The electrostatic force between two small charged spheres having charges of 2×10^{-6} C and 3×10^{-6} C placed 30 cm apart in air is
(a) 0,9 N (b) 0.6 N (c) 1.2 N (d) 1.8 N

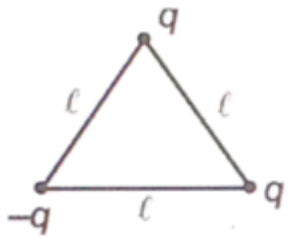
2. Four point charges $q_A = -2\mu C, q_B = -5\mu C, q_c = -2\mu C$ and $q_D = -5\mu C$ are located at the corners of a square of side 20 cm (In cyclic order). What is electric force on a charge of $1\mu C$ placed at the centre of square?
(a)0.9N (b) Zero (c) 0.6 N (d) 2.4 N

3. A system of two charges $q_A = 2.5\times10^{-7}C$ and $q_B = -2.5\times10^{-7}C$ are located at points A: (0. 0,-15 cm) and B: (0. 0, 15 cm) respectively. The electric dipole moment of system is
(a) $2.5\times10^{-7}Cm$ (b) $5\times10^{-7}Cm$
(c) $7.5\times10^{-8}Cm$ (d) Zero

4. A polythene piece rubbed with wool is found to have negative charge of $3.2\times10^{-6}C$. The number of excess electrons on polythene is
(a) 2×10^{13} (b) 4×10^{12} (c) 5.5×10^{9} (d) 6×10^{20}

5. An electron falls through distance of m in uniform electric field from state of rest. The time of fall if $E = 6\times10^{4}\ NC^{-1}$ is
(a) $1.5\times10^{-6}s$ (b) $1.94\times10^{-9}s$
(c) $3.3\times10^{-5}s$ (d) $2.3\times10^{-6}s$

6. Consider charges q,-*q* and *q* placed at vertices of an equilateral triangle as shown in figure. Calculate force on -*q* charge due toother



1) $\frac{q^2}{2\pi\varepsilon_0\ell^2}$ 2) $\frac{q^2}{4\pi\varepsilon_0\ell^2}$ 3) $\frac{\sqrt{2}q^2}{\pi\varepsilon_0\ell^2}$ 4) $\frac{\sqrt{3}q^2}{4\pi\varepsilon_0\ell^2}$

7. Which among the given statements is incorrect statement?
(a) For every positive point charge, electric field lines will be directed radially outwards from charge.
(b) Magnitude of electric field *E* will depend on distance form point charge
(c) The electric field due to a point charge has spherical symmetry
(d) A test charge *q* experiences electric force $\vec{F}$ at a point then electric field intensity is defined as $\vec{E} = \frac{\vec{F}}{q^2}$

8. A proton and an electron are released form rest in uniform electric field then the correct Statement among the following is
(a) Time required to fall through certain distance is more for an electron
(b) The force experiences by proton will be more

(c) Magnitude of acceleration experienced by proton is more
(d) KE gained by both charges in moving through same distance are equal

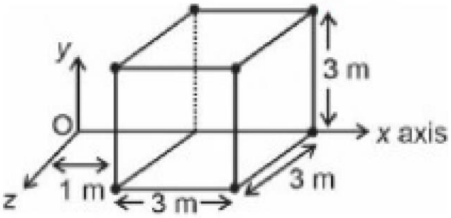
9. Regarding electric lines of force, the correct statement is/are
(a) Field lines carry information about direction of electric field
(b) Relative density of field lines at different points indicates relative strength of electric field at these points
(c) The field lines crowd where field is weak and spaced apart where field in strong
(d) Beth (a) and (b) are correct

10. The incorrect statement among the following statements is
(a) Electric field lines can never cross each other
(b) Electrostatic field lines do not form any closed loop
(c) In charge free region, electric field lines can be taken to be continuous curve
(d) Field lines around a system of two positive charges is straight and parallel lines pictorially

11. A dipole consist of two charges q and $-q$ separated by a distance 2a. The electric field of this dipole at distance r from centre of dipole at a point ***A*** on axis is

1) $\frac{2p}{4\pi\varepsilon_0 r^2}$ 2) $\frac{2p}{4\pi\varepsilon_0 (r^2+a^2)^{\frac{3}{2}}}$ 3) $\frac{p}{4\pi\varepsilon_0 r^3}$ 4) $\frac{2pr}{4\pi\varepsilon_0 (r^2-a^2)^2}$

12. Electric field components are $E_x = 100x^{\frac{1}{2}}, E_y = E_z = 0$. Calculate net electric flux though the cube placed in electric field at shown position.



(a) 900Nm²C⁻¹ (b) 1800Nm²C⁻¹ (c) 600 Nm²C⁻¹ (d) 3600 Nm²C⁻¹

13. An infinite long straight wire has linear charge density $\lambda = 4\times10^5 Cm^{-1}$. The electric force experienced by a proton at perpendicular distance of 10 mm from axis of wire is

(a) 1.25 **x**10⁻⁴ N (b) 1.68 **x**10⁻³N
(c) 2.8 **x**10⁻⁶N (d) 1.15 **x**10⁻¹ N

14. Coulomb's law of electrostatic for the force between two point charges most closely resembles
(a) Law of conservation of charges
(b) Law of conservation of energy
(c) Newton's second law of motion
(d) Newton's law of gravitation

15. A point charge q of mass m is placed in front of a uniformly charged infinite sheet and released. The surface charge density of sheet is C m⁻². The kinetic energy of charge after t second is

1) $\frac{q^2\sigma^2t^2}{4\varepsilon_0^2 m}$ 2) $\frac{q^2\sigma^2t^2}{\varepsilon_0^2 m}$ 3) $\frac{q^2\sigma^2t^2}{8\varepsilon_0^2 m}$ 4) $\frac{q^2\sigma^2t^2}{4\varepsilon_0^2 m}$

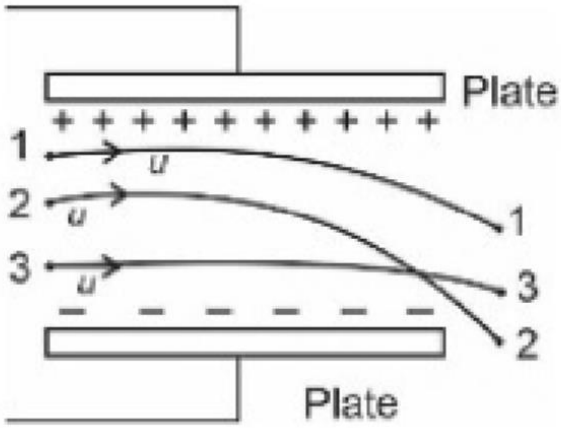
16. An electric dipole consists of two equal and opposite charges 002 μC separated by 2 mm. The dipole is placed is uniform electric field of 10^7 N C⁻¹. Maximum torque exerted by field on dipole is
(a) 2×10^{-4} Nm (b) 4×10^{-4} Nm

(c) 8×10^{-4} Nm (d) 2×10^{-6} Nm

17. A thin spherical shell is given a charge q = **4** μC, uniformly distributed over its surface. Consider a point *P* outside the shell at distance of 2 m from surface. If the radius of shell is 1 m, what is electric field at point *P?*

(a) 4kNC-1 (b) 2kNC-1 (c) 9 kN C-1 (d) 36 kN C-1

18. Figure shows track of three positive charged particles through uniform electric field E. All charges are equal in value. Which charge particle has more initial kinetic energy on entering horizontally between the plate?



(a) Particle 1 (b) Particle 2
(c) Particle 3 (d) Both 1 and 2 have equal initial KE

19. A uniformly charged conducting sphere of 3 m diameter has a Surface charge density of 90 μC/m^2. What is total electric flux leaving the surface of sphere?

(a) 1.76×10^{8} N m^{2}C^{-1} (b) 2.87×10^{8} N m^{2}C^{-1}
(c) 5.2×10^{8} N m^{2}C^{-1} (d) 4.52×10^{6} N m^{2}C^{-1}

20. Incorrect statement among the following is
(a) Gauss's law is useful in calculating electric field when system has some symmetry
(b) Gaussian surface can pass through a continuous charge distribution
(c) Gauss's law is based on inverse square dependence of electric field on distance
(d) In situation when surface is so chosen that some charges are outside and some inside, electric field (whose flux appears on left side of Gauss's equation) is only due to the charges inside the closed surface

NCERT BASED PRACTICE QUESTIONS

21. The electric intensity at any point between two oppositely charged plain sheets is
(a) s/3Îo (b) s/Îo
(c) s/2Îo, (d) 2s/Îo

22. The electric potential is zero
(a) Inside a conductor
(b) Midway between any two charges of the opposite signs
(c) Midway between two equal charges of the sme sign)
(d) none

23. The magnitude of an electric field does not depend upon
(a) The distance from the charged particle
(b) nature of the charges causing the field,
(c) the magnitude of the charges causing the field
(d) none

24. A free electron in an electric field
(a) remains stationary,
(b) moves from the higher potential to the lower potential,
(c) moves from the lower potential to the higher potential
(d) none

25. Electric intensity of a given charge at any point is distance from charge.
(a) Directly proportional to,
(b) Inversely proportional to square of,
(c) Directly proportional to square of,
(d) Inversely proportional to square of

26. A slab of certain dielectric is placed between two oppositely charge plates. The intensity between plates
(a) Decreases, (b) Increases,
(c) Remains constant (d) none

27. Matter is composed of three fundamental particles. They are
(a) Electrons, Protons, Neutrons
(b) Electrons, Cathode rays, masons
(c) Electrons, neutrons, masons
(d) none

28. is a negatively charged particle and is found around the nucleus of an atom.
(a) Electron, (b) Proton,
(c) Neutron, (d) None of these

29. When one or more than one electrons are removed from an atom it becomes .
(a) Neutral particle, (b) Negatively charged particle,
(c) positively charged particle, (d) none of these

30. If the quantity of charge on each of the two bodies is doubled, the force between them becomes
(a) Twice, (b) Four times,
(c) Nine times, (d) Sixteen times

31. A charge q is placed at the centre of the line joining two equal charges Q. The system of the three charges will be in equilibrium if q is equal to...
(a) -(Q/2) (b) -(Q/4)
(c) +(Q/4) (d) +(Q/2)

32. The total electric flux is...
(a) always positive (b) always negative
(c) always zero (d) none of the above

33. Electric charge is quantized. This means that the electric charge...
(a) is not continuous (b) is continuous
(c) is constant (d) has mass

34. Two equal negative charges(-q) are fixed at two points (0,a) and (0,-a) on the Y-axis. A positive charge q is released from rest at the point (2a,0) on the X-axis. The charge q will...
(a) execute SHM about the origin

(b) move to the origin and remain at rest

(c) move to infinity

(d) execute oscillatory motion but not SHM.

35. Electric field at x =10 cm is 100i V/m and at x = -10 cm is -100 iV/m. The magnitude of charge enclosed by the cube of side 20 m is

(a) 8 c (c) 2 c (b) 3 c (d) 5 c

36. A thin metal plate p is inserted between the plates of a parallel plate capacitor of capacitance C in such a way that its edge touch the two plates forming Z shape . The capacitance now becomes:

(a) C/2 (b) 2C (c) zero (d) infinite

37. Three point charges are located on the x-axis. The first charge, q_1 = 10 μC, is at x = -1.0 m. The second charge, q_2 = 20 μC, is at the origin. The third charge, q_3 = - 30 μC, is located at x = 2.0 m. What is the force on q_2?

(a)1.65 N in the negative x- direction (b)3.15 N in the positive x- direction

(c)1.50 N in the negative x- direction (d)4.80 N in the positive x- direction

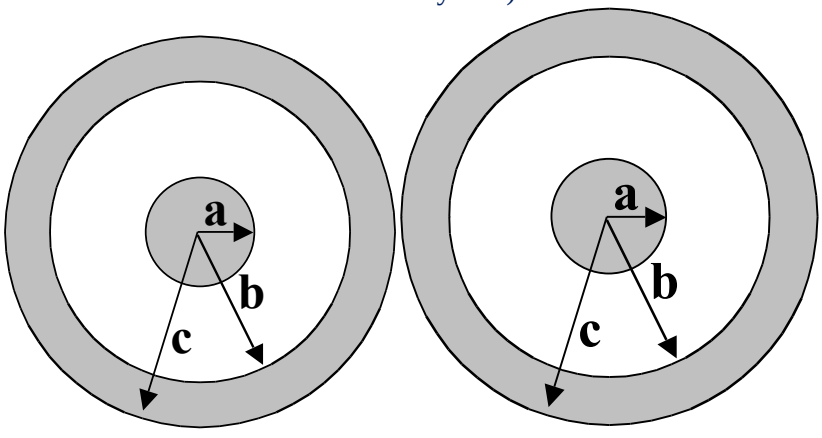
38. The electric field has a magnitude of 3.0 N/m at a distance of 60 cm from a point charge. What is the charge?

(a)1.4 nC (b)120 Pc (c)36 mC (d)12 μC

39. An electron traveling horizontally from North to South enters a region where a uniform electric field is directed downward. What is the direction of the electric force exerted on the electron once it has entered the field?

(a)downward (b)upward (c)to the east (d)to the west

40. A solid conducting sphere or radius A carries an excess charge of +6 μC. This sphere is located at the center of a hollow conducting sphere with an inner radius of B and an outer radius of C as shown. The hollow sphere also carries a total excess charge of +6 μC. Determine the excess charge on the inner surface of the outer sphere (a distance of B from the center of the system).



(a) zero (b) - 6 μC (c) + 6 μC (d) + 12 μC

41. A 1.65 nC charge with a mass of 1.5 x 10^{-15} kg experiences an acceleration of 6.33 x 10^7 m/s^2 in an electric field. What is the magnitude of the electric field?

(a) 57.6 N/C (b) 1.65 x 10^{-9} N/C (c) 14.9 N/C (d) 2.67 x 10^{-19} N/C

42. An electric dipole is surrounded by a closed surface with the surface nearer to the negative end of the dipole than the positive end. The flux through the surface is.

(a) positive. (b) negative.

(c) proportional to the negative charge. (d) inversely proportional to the positive charge.

43. What is the potential at a distance of 0.0529 nm from a proton?

(a) 13.6 nV (b) -13.6 nV (c) 27.2 V (d) -27.2 nV

44. A parallel plate capacitor with an air dielectric is attached to a voltage source and charged. The voltage source is removed, and then the plates are separated to double their previous distance. What happens to the energy stored by the capacitor when the plates are separated?

(a) it doubles (b) it quadruples

(c) it halves (d) it is diminished by a factor of 4

45. An electron is accelerated from rest through a potential difference *V*. If the electron reaches a speed of 9.11×10^6 m/s, what is the potential difference?

(a) 236 V (b) 83.7 V (c) 24.9 V (d) 0.626 V

46. A parallel plate capacitor with plates of area A and plate separation d is charged so that the potential difference between the plates is V. If the capacitor is then isolated and its plate separation is decreased to d/2, what happens to its capacitance?

(a) The capacitance is twice its original value. (b) The capacitance is four times its original value.

(c) The capacitance is eight times its original value.

(d) The capacitance is one half of its original value.

47. A parallel plate capacitor has plates each of area 0.01 m^2 and with separation 0.25 mm. What is its capacitance?

(a) 40 nF (b) 0.35 nF (c) 4.4 μF (d) 88 pF

48. A parallel plate capacitor is attached to a voltage source providing 12 V. When an insulator of dielectric constant 6.0 is then used to fill the air space between the capacitor plates, what happens to the surface charge density on the plates if the voltage source is still attached?

(a) It increases by a factor of 6.0 (b) It increases by a factor of 2.0

(c) It decreases by a factor of 6.0 (d) It decreases by a factor of 2.0

49. If there is a force of 5.0 x 10-12 N acting to the left on an electron, the electric field intensity at the location of this electron will be:

(a) zero. (b) 8.0×10^{-31} N/C to the left

(c) 3.1×10^7 N/C to the left (d) 3.1×10^7 N/C to the right

50. In one mole or 18 grams of water, the total negative charge of all the electrons is:

(a) zero because its electrically neutral. (b) less than one C

(c) almost 100,000 C. (d) almost one million C.

51. Consider three identical metal spheres that are mounted on insulating stands. Sphere X is neutral, sphere Y has a charge -1q, and sphere Z has a charge +4q. Y and Z are touched together and then separated.

(a) Each is now charged, with a charge +1.5 q

(b) Each is now charged, with a charge +2.5 q

(c) Each is now charged, with a charge +3 q

(d) Sphere Y has charge +4 q, sphere Z now has charge -1 q

52. Consider a small, conducting sphere of 0.0010 kg mass. Extra electrons are added to this sphere and an identical sphere below it so that the excess charge on the top sphere is three times that on the lower one. How much extra charge would have to be placed upon the top sphere so that the electrical repulsion between the extra charge on these spheres would provide a force equal to the weight of the sphere when the spheres are 4.0 m apart?

(a) 5.8 x 10-12C (b) 2.4 x 10-6 C

(c) 3.6 x 10-6 C (d) 7.2 x 10-6 C

53. Consider a small, conducting sphere of 0.0010 kg mass. Extra electrons are placed on this sphere and on an identical sphere 3.0 m below it so the repulsion between these extra electrons provides a force equal to the weight of the top sphere. How many electrons must be added to each sphere?

(a) 5.0×10^{-25} (b) 3.1×10^{-6} (c) 2.0 x 1013 (d) 3.9×10^{13}

54. Electrical charge interaction can be summarized by:

(a) - charge repels other - charge. (b) + charge repels other + charge.

(c) - charge and + charge attract each other. (d) All of these.

55. Consider two point charges that are separated by a distance, 2r. If this distance between them is increased to 5 r, the force between the charges is:

(a) 1/25 as great as it had been (b) 4/25 as great as it had been

(c) 1/9 as great as it had been (d) 25 times as great as it had been

56. The electric field is zero:

(a) inside any conductor.

(b) inside any conductor with a static charge.

(c) inside any material, conductor or insulator, with a static charge.

(d) Never.

57. If the symbols] and [are used to represent a pair of charged plates, in the sketch below, +] [- the field between the two plates would be directed:

(a) upward. (b) to the left.

(c) to the right. (d) zero, so its direction would be without meaning.

58. Consider three identical metal spheres that are mounted on insulating stands. Sphere X is neutral, sphere Y has a charge -1q, and sphere Z has a charge +4q. X and Y are touched together and then separated.

(a) Each is now charged, with a charge -0.5 q.

(b) Each is now charged, with a charge -1 q

(c) Sphere X is neutral, sphere Y has a charge -1q

(d) Sphere X has charge -1 q, sphere Y is now neutral

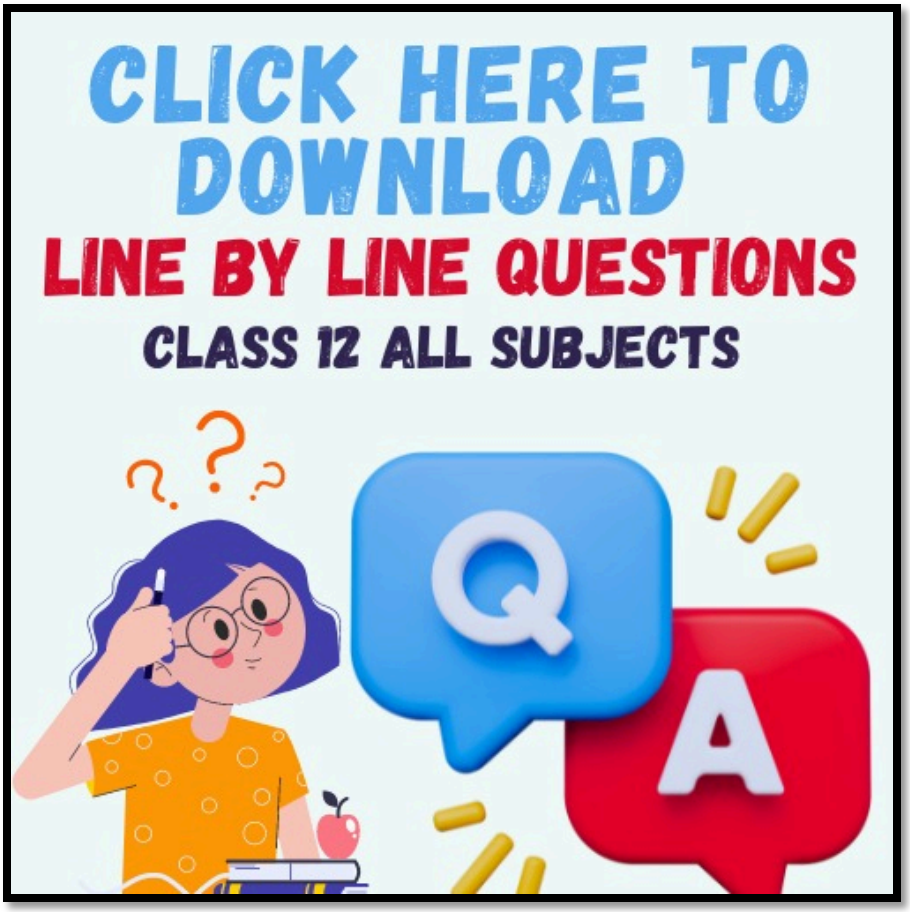
59. A capacitor and resistor are connected in a series with a batter and a switch. The instant after the switch is closed

(a) the voltage across the resistor is equal to the emf of the battery

(b) the voltage across the capacitor is equal to the emf of the battery

(c) the voltage across the resistor is equal to zero

(d) the current is equal to zero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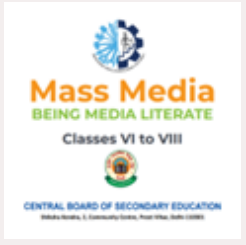

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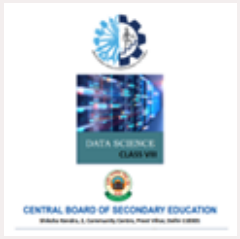

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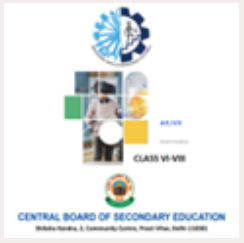

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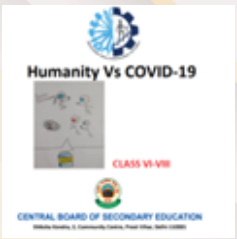

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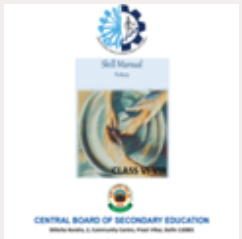

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